Bio-Based Soil-Applied Products for Enhancing Growth and Disease Control in Vegetables and Strawberries’

South Central Soil Summit 2017

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Symbiotic Soil Relationships

Beneficial fungi and bacteria are abundant in soils

Protecting and enhancing your soil environment will improve crop growth and plant resistance to pests

A teaspoon of productive soil generally contains between 100 million and 1 billion bacteria!
What are Bio-Based Products?

Products determined by the Agriculture Secretary to be a commercial or industrial product (other than food or feed) that is composed, in whole or in significant part, of biological products or renewable domestic agricultural materials (including plant, animal, and marine materials)...

- Natural products
- Biocontrol products
  - Only EPA registered biopesticides can make claim of pesticidal activity or control.
- Soil/microbe enhancers
- Compost products
- Snake oils?

Natural products
Biocontrol products
Soil/microbe enhancers
Compost products
Snake oils?
Rhizobia – nitrogen fixing bacteria

BACTERIA

Don’t confuse root knot nematodes with Rhizobia!
There are many, many soil inoculants available… typically not labeled as biopesticides, but growth enhancers. They help to expand the plant’s root system increasing nutrient and water uptake.
Effect of *Mycorrhiza* application on tomato transplants

Wallace, 2008. Texas A&M AgriLife
Compost Teas

Generally homemade products... we won’t be discussing those. While useful, there are too many variations in final products... often there is a lack of quality control or EPA registration.

Good for adding/increasing microbes into the soil.

Benefits: Healthier soils/plants and potential disease suppression.
Why use bio-based products as biopesticides?

- Increase soil and/or plant health
- Improve nutrient and moisture uptake
- Reduce plant biotic/abiotic stresses
Why use bio-based products as biopesticides?

Disease control and suppression
What Are Biopesticides?

“Biopesticides are types of [registered] pesticides derived from such natural materials as animals, plants, bacteria, fungi and certain minerals. For example, canola oil and baking soda have pesticidal applications and are considered biopesticides. As of April 2016, there are 299 registered biopesticide active ingredients and 1401 active biopesticide product registrations.” www.epa.gov

Classes of Biopesticides

1. Naturally occurring substances
2. Microorganisms (bacteria, fungi, viruses, etc.)
3. Plant-Incorporated-Protectants (products from plant genetic materials)
Biopesticide Products

- Alternative options to chemicals in organic production.
- Many of these products came out of university research programs.
- New products and uses are being registered all the time. Work with companies to evaluate suggested applications and use rates. Biocontrol companies want university recommendations.
- From personal experience, biopesticides have significant benefits but also limitations. They can be influenced by soil (temp., pH, % OM, etc.) and climatic environments, just like plants.
Biopesticide Products

- Be cautious about what you purchase – purchase those tested and proven by unbiased researchers

- Best to get advice from non-biased researchers/extension specialists with experience using the products

- For best results, always follow the company’s instructions on the registrations/labels

- Always store the products according to the label or living products may die prior to expiration dates
Modes of Action for Biopesticides

1. Improve plant growth/health for better defense
2. Competitive exclusion
3. Induced Systemic Resistance
4. Production of metabolites that kill fungal and bacterial pathogens
Increased Plant/Root Health

Foliage is similar but roots are different sizes.

Improved plant size and likely improved germination.
Mode of Action: ISR

- Induced systemic resistance (ISR)
- It is a mechanism by which selected plant growth-promoting bacteria and fungi in the soil prime the whole plant for enhanced defense against certain diseases and insects.
- A wide variety of root-associated beneficial fungi and bacteria, including *Pseudomonas*, *Bacillus*, *Trichoderma*, and *Mycorrhiza* species sensitize the plant’s immune system for enhanced defense without directly activating costly defenses (or yield losses).
- Similar to a vaccine inoculation…

Pietersen, et al. Plant-Microbe Interactions, Institute of Environmental Biology, Department of Biology, Faculty of Science, Utrecht University, 3508 TB Utrecht, The Netherlands
Most living biologicals work through competitive exclusion.

What is it?

The competitive exclusion principle, sometimes referred to as Gause's Law of competitive exclusion states that two species that compete for the exact same resources cannot stably coexist.

In other words the one there wins!

Ex: *Trichoderma harzianum* growing competitively on corn roots
Biopesticide Modes of Action

BACTERIA

**Bacillus amyloliquefaciens** (FZB 42 and D747)
- MOA: **Competitive exclusion** of pathogens
- Applied to both soil and hydroponic systems
- Control/suppression of *Rhizoctonia, Pythium, Fusarium*
- Also improves plant tolerance to abiotic stresses and improved salt tolerance, and nutrient uptake

**Streptomyces lydicus** WYEC 108
- MOA: **Competitive exclusion** of the pathogen and by production and secretion of antifungal metabolites.
- Control/suppression of *Rhizoctonia, Pythium, Fusarium*
- Improve root systems

Applications can last 4 – 8 weeks
Biopesticide Modes of Action (MOA)

**Fungi**

- *Trichoderma harzianum, T. virens, T. asperellum, etc.*
  - Grow on plant roots “shielding” (*competitive exclusion*) them against pathogens like *Fusarium, Rhizoctonia, Pythium, Phytophthora*, etc.
  - Release enzymes that dissolve the cell wall of many fungal pathogens
  - Promote ‘healthier root systems’ increasing root mass potential, improving nutrient and moisture uptake
  - A single application can provide 6 to 12 weeks of protection

T. harzianum entry point
Plant Extracts: Regalia

- **Modes of action:**
  - **Induced Systemic Resistance (ISR)** - Activates natural plant defense mechanisms by stimulating the plant’s innate ability to fight diseases.
  - **Extract of *Reynoutria sachalinensis* (leaves of giant knotweed)**
    - Treated cells signal an infection
    - Produces antimicrobial compounds that inhibit pathogens
    - Strengthen cell walls to act as a physical barrier
    - Multiple applications needed
Mode of action:

- *Brassica* species, produce glucosinates, when they come in contact with water and myrosinase enzyme (in plant cells) it is transformed into the biofumigant isothiocyanate (mustard gas).

- Needs to be incorporated and watered.
- Sealed with plastic to prevent gases escaping.
- Use 1 – 2 weeks prior to seeding or transplanting.
- Comes in pelleted form or can grow and incorporate as a green crop.
Biopesticide Industry Alliance is dedicated to fostering adoption of biopesticide technology through increased awareness about their effectiveness and full range of benefits to a progressive pest management program.
What are we doing?

- Strawberry project funded by USDA-SARE (Sustainable Agriculture Research and Education) from 2016 - 2019.

- A collaborative effort between Texas A&M AgriLife Extension, the University of Arkansas, Prairie View A&M University and the Texas Organic Farmers and Gardeners Association and 5 – 7 strawberry growers.

- Main emphasis is on small-acreage and limited-resource organic growers who need information on successful and cost-effective biocontrol products (both soil and foliar) to control pests in strawberries.
Our Project Objectives

- Evaluate the efficacy of selected commercial biopesticides (different active ingredients)
- Evaluate costs of using these products
- Provide training opportunities for growers
- Publish a *Biocontrol Guide for Strawberries*
Products We Are Evaluating

Root Disease Control: Strawberries

- Actinovate AG – (Streptomyces lydicus WYEC 108)
- **AmyProtec 42** – (Bacillus amyloliquefaciens FZB 42)
- Double Nickel – (Bacillus amyloliquefaciens D747)
- Regalia – (Extract of Reynoutria sachalinensis)
- RootShield Plus – (Trichoderma harzianum + T. Virens)
- BioSense – Caliente mustard 199 (Brassica spp.) pellets (isothiocyanate produced for biofumigation)

* Not yet labeled in US

Products applied as root drenches to plants at transplanting and up to 6 times during the season through the drip irrigation.
Number of *Rhizoctonia*-Infected Plants with Biopesticide Treatments in a High Tunnel Strawberry Production System

27% higher infections

30 plants/plot, applied 3 times during season
Marketable Strawberry Yields in Response to Biopesticide Root Treatments in a High Tunnel

- **RootShield Plus**: 12% higher yield
- **AmyProtec 42**
- **Regalia**
- **Actinovate**
- **RootShield Plus + Regalia (0.5X)**

Average no. lbs/plot:
- Untreated: 30
- RootShield Plus: 35
- AmyProtec 42: 30
- Regalia: 30
- Actinovate: 30

30 plants/plot, applied 3 times during season
# 2017 – 2018 Biopesticide Trials

## Strawberry Soil-Applied Bio-Based Evaluation for Root Disease Control in Low and High Tunnels

<table>
<thead>
<tr>
<th>Trt No.</th>
<th>Treatment</th>
<th>Active Ingredient</th>
<th>Timing (T = at transplanting)</th>
<th>Product Rate/A (via drip irrigation)</th>
<th>Rate/10’ x 2.5’ plot in 2.0 gallons water</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Untreated</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Abound FL + Ridomil Gold</td>
<td>Azoxystrobin + Acifluorfen</td>
<td>T + 8 wks + 16 wks</td>
<td>0.6 oz/1,000 ft row + 1.0 pt/A</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>BioSense 6-2-0</td>
<td>Caliente mustard pellets</td>
<td>Applied by hand 2 weeks before planting under mulch</td>
<td>1.25 lbs per 10’ ft-row</td>
<td>1.25 lbs/10’ row</td>
</tr>
<tr>
<td>4</td>
<td>Actinovate</td>
<td>Streptomyces lydicus WYEC 108</td>
<td>T + 8 wks + 16 wks</td>
<td>6.0 oz.</td>
<td>0.2 gms</td>
</tr>
<tr>
<td>5</td>
<td>Actinovate</td>
<td></td>
<td>T + 4 wks + 8 wks + 12 wks + 16 wks + 20 wks</td>
<td>6.0 oz.</td>
<td>0.2 gms</td>
</tr>
<tr>
<td>6</td>
<td>AmyProtec 42</td>
<td>Bacillus amyloliquefaciens FZB 42</td>
<td>T + 8 wks + 16 wks</td>
<td>14.0 oz.</td>
<td>0.48 mls</td>
</tr>
<tr>
<td>7</td>
<td>AmyProtec 42</td>
<td>Bacillus amyloliquefaciens strain D747</td>
<td>T + 4 wks + 8 wks + 12 wks + 16 wks + 20 wks</td>
<td>1.0 quart</td>
<td>1.08 mls</td>
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<tr>
<td>8</td>
<td>Double Nickel</td>
<td>Extract of Reynoutria sachalinensis</td>
<td>T + 4 wks + 8 wks + 12 wks + 16 wks + 20 wks</td>
<td>2.5 quarts</td>
<td>2.72 mls</td>
</tr>
<tr>
<td>10</td>
<td>Regalia</td>
<td>Trichoderma Harzianum + T. Virens</td>
<td>T + 4 wks + 8 wks + 12 wks + 16 wks + 20 wks</td>
<td>8.0 oz per 100 gallons</td>
<td>3.41 gms</td>
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<tr>
<td>11</td>
<td>Regalia</td>
<td></td>
<td>T + 4 wks + 8 wks + 12 wks + 16 wks + 20 wks</td>
<td>8.0 oz per 100 gal for T and 4 wks; followed by 6.0 oz/100 gal 8,12,16 7 20 wks</td>
<td>4.54 gms = 8.0 oz 3.41 gms = 6.0 oz</td>
</tr>
</tbody>
</table>

*Texas A&M AgriLife Extension*
Industry Collaborators: 2017 - 2018

- Andermatt Biocontrol AG
  - AmyProtec 42
- BioWorks, Inc.
  - RootShield Plus
- Certis, USA
  - Double Nickel
- Marrone Bio Innovations
  - Regalia
- Valent
  - Actinovate AG
Bio-based products are generally beneficial to crop growth. Can improve health and overall growth/yield. Soil and climate environments important to success.

Improving your soil’s health will increase the level of beneficial fungi and bacteria in your soil.

While there are proven benefits, when considering these products, best to get local university recommendations.

Do your own testing on small area before treating whole farm.
Biopesticides are microbial or plant-based products that help to control or suppress soil diseases (and foliar diseases and insects).

To make pesticide claims, they must be EPA-registered scientifically-tested products.

- Bacteria, Fungi and Plant Extracts

- **Modes of Action by Biopesticides**
  - Competitive exclusion
  - Induced Systemic Resistance
  - Enzymatic reactions
Thanks... Any questions?